(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平6－308471

(43)公開日　平成6年(1994)11月4日

(51)Int.Cl.⁵		識別記号	庁内整理番号	F I	技術表示箇所
G02F	1/1333		9317－2K		
	1/13	101	8707－2K		
		505	9119－2K		

審査請求　未請求　請求項の数2　OL　（全 12 頁）

(21)出願番号　特願平5－296287

(22)出願日　平成5年(1993)11月26日

(31)優先権主張番号　特願平5－33221

(32)優先日　平5(1993)2月23日

(33)優先権主張国　日本（ＪＰ）

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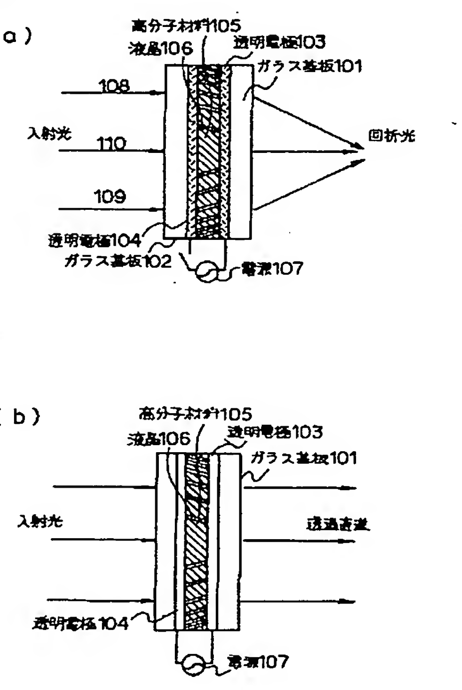
(54)【発明の名称】　光学素子とその製造方法

(57)【要約】

【目的】　回折／直進または反射／直進が電気的に制御可能で、入射平行光に対する回折光または反射光が収束または分散できる光学素子を得る。

【構成】　回折光または反射光が入射平行光に対し収束または分散するように、液晶領域１０６と高分子領域１０５とを平面的または立体的に配置する。

図1



【特許請求の範囲】

【請求項１】液晶と高分子材料とからなり屈折率が異なる複数の領域を有し、電界により上記液晶の屈折率を変化させ、入射光の回折／直進または反射／直進を制御可能にした光学素子において、上記回折光または反射光が入射平行光に対し収束または分散するように、上記液晶領域と上記高分子領域とを平面的または立体的に配置したことを特徴とする光学素子。

【請求項２】液晶と高分子材料とからなり屈折率が異なる複数の領域を有し、電界により上記液晶の屈折率を変化させ、入射光の回折／直進または反射／直進を制御可能にした光学素子の製造方法において、上記高分子材料に光または熱硬化性樹脂を用い、複数の光束を制御したレーザ光を上記液晶と光または熱硬化性樹脂との混合物に照射し、レーザの干渉パタンによる光の強弱層により液晶と高分子材料とを分離して、上記液晶の領域と上記高分子材料の領域とを配置することを特徴とする光学素子の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、光の回折／直進または反射／直進を電気的に制御可能で、入射平行光に対する回折光と反射光が収束または分散する光学素子とその製造方法に関するものである。

【０００２】

【従来の技術】電圧によって光の回折／直進または反射／直進を制御することができる光学素子を、われわれは発明した（特願平３－２９５６１７号および特願平３－３４１５３１号）。光の回折／直進を制御する光学素子の構造を図２５に示し、光の反射／直進を制御する光学素子の構造を図２６に示す。これらの光学素子は透明電極１００３および１００４の間に高分子材料１００５の領域と液晶１００６の領域とからなる周期構造を形成している。液晶は電界により屈折率が変化するため、液晶と高分子材料との屈折率差を変化させることができる。図２５において、液晶と高分子材料との屈折率差が大きい場合には、位相形回折格子の原理（例えば「光学の原理」、ボルン、ウォルフ著、東海大学出版を参照）に従い、光を回折する。また、電圧を印加して液晶の屈折率を変え、高分子材料と液晶との屈折率差を小さくすると回折格子の構造が消失し、光をそのまま直進させることができる。したがって、光の回折／直進が制御できる。一方、図２６において液晶と高分子材料の屈折率差が大きい場合には、多層膜の光学的性質から特定波長の光を反射する。また、電圧を印加して液晶の屈折率を変え、高分子材料と液晶との屈折率差を小さくすると、上記多層構造が消失し光をそのまま直進させることができる。したがって、光の反射／直進を制御できる。

【０００３】

【発明が解決しようとする課題】しかしながら、上記光学素子においては、平行な入射光を平行光として回折および反射するものであった。このため、回折光および反射光を収束または分散するためには、レンズなどの光学素子を別途に設ける必要があり、光の収束または分散を必要とする光学装置に適用するには、構成が複雑になるという問題があった。

【０００４】本発明は、回折／直進または反射／直進が電気的に制御可能であり、さらに、入射平行光に対する回折光および反射光が収束または分散するように、レンズなどの光学素子機能を備えた光学素子を得ることを目的とする。

【０００５】

【課題を解決するための手段】上記目的は、液晶と高分子材料とからなる屈折率が異なる複数の領域を有し、電界により上記液晶の屈折率を変化させ、入射光の回折／直進または反射／直進を制御可能にした光学素子において、上記回折光または反射光が入射平行光に対し収束または分散するように、上記液晶領域と上記高分子領域とを平面的または立体的に配置することにより達成される。

【０００６】また、上記高分子材料に光または熱硬化性樹脂を用い、複数の光を制御したレーザ光を上記液晶と光または熱硬化性樹脂との混合物に照射し、レーザの干渉パタンによる光の強弱層によって、液晶と高分子材料とを分離して各領域を配置して上記光学素子を製造することにより達成できる。

【０００７】

【作用】本発明の光学素子は、電界により液晶の屈折率を変化させ、光の回折／直進または反射／直進を制御することが可能であり、かつ、上記回折光または反射光を収束あるいは分散するように、レンズ等のように光の光束を制御する光学素子としての機能を持たせることができる。このため、レンズ等の光学素子を別途に設ける必要がなく、光学装置の構成が簡単になる。

【０００８】また、回折光または反射光が収束または分散するように液晶の領域と高分子材料の領域とを配置するために、上記高分子材料の原料としては光または熱硬化性樹脂を用い、複数の光束を制御したレーザ光を上記液晶と光または熱硬化性樹脂との混合物に照射し、レーザの干渉パタンによる光の強弱層によって、上記液晶と上記高分子材料とを分離する。上記手法を用いると、レーザ光の光束を干渉パタンとして記録しているため、ホログラフィの原理（例えば「ホログラフィ」大越孝敬著、電子通信学会編、１９７７年を参照）に従い、照射したレーザ光の光束を再現することができる。すなわち、光学素子作製時に照射するレーザ光の光束を制御することによって、多種多様の回折光束や反射光束を再現することができ、かつ、上記回折光および反射光を電気的に制御可能な光学素子を形成することができる。また、レーザ照射だけの極めて簡単な作製方法で上記光学

素子を作製することができる。

【０００９】

【実施例】つぎに本発明の実施例を図面とともに説明する。図１は本発明による集光した回折光を得るための光学素子を示す図、図２は回折光を分散させる光学素子を示す図、図３は回折光を複数領域で集光できる光学素子を示す図、図４は回折光を複数領域で分散できる光学素子を示す図、図５は回折光の集光位置が素子の中央部からずれている光学素子を示す図、図６は高分子材料内部に液晶ドロップレットが形成されている光学素子で、（ａ）は周期的に分布している素子、（ｂ）は不均一に形成されている素子を示す図、図７は上記集光した回折光を得る光学素子の形成方法を示す図、図８は上記光学素子に対するレーザ照射方法を示す図、図９は本発明による集光した反射光を得るための光学素子を示す図、図１０は反射光を分散させる光学素子を示す図、図１１は複数の集光領域を有する光学素子を示す図、図１２は複数の分散領域を有する光学素子を示す図、図１３は反射光の集光位置を光学素子中央部からずらせた光学素子を示す図、図１４は上記集光した反射光を得る光学素子の形成方法を示す図、図１５は上記光学素子に対するレーザ照射方法を示す図、図１６は２種類の液晶と高分子からなる回折格子を同一領域に有する光学素子を示す図、図１７は上記光学素子の形成方法を示す図、図１８は２種類の液晶と高分子からなる多層構造の回折格子を同一領域に有する光学素子を示す図、図１９は上記光学素子の形成方法を示す図、図２０は回折格子構造と多層構造とを同一領域に有する光学素子を示す図、図２１は上記光学素子の形成方法を示す図、図２２は本発明の光学素子を複数平面配置した光学装置を示す図、図２３は本発明の光学素子を複数平面配置した他の光学装置を示す図、図２４は本発明の光学素子を複数積層使用した光学装置を示す図である。

【００１０】第１実施例

本発明による光学素子の第１実施例として、集光した回折光を得るための光学素子とその動作原理を図１に示す。本実施例の光学素子は図１（ａ）に示すように、例えばガラス基板１０１および１０２上に形成した膜厚５００ÅのＩＴＯ膜による２つの透明電極１０３と１０４との間に、屈折率ｎ３の光または熱硬化型高分子材料（例えば熱硬化性樹脂：エポキシ樹脂（ｎ３＝１．５）、あるいは光硬化性樹脂：ラックストラックＬＡＯ２０８（ｎ３＝１．５）が硬化した高分子材料）による領域１０５と、屈折率が電界によってｎ１からｎ２まで可変なネマティック液晶（例えばメルク社製Ｅ－７：ｎ１＝１．７５、ｎ２＝１．５２）による領域１０６とを、間隔を変えて配列している。また、１０７は上記ネマティック液晶１０６の屈折率を変化させるための電源である。

【００１１】上記光学素子においては、高分子材料１０５と液晶１０６とを交互に配置し、中心部になるほど高分子材料１０５と液晶１０６との周期が長くなるように配置してある回折格子の構造を有している。また、上記高分子材料１０６と上記液晶１０５の界面と入射光とがなす角度を、回折光が本発明の光学素子の中心部に向くように設定してある。上記光学素子は図１（ａ）に示すように、透明電極１０３と透明電極１０４との間に電源１０７により電圧を加えないと、液晶による領域１０６の屈折率をｎ１とするとき、全体として屈折率がｎ３／ｎ１／ｎ３…ｎ３／ｎ１／ｎ３（ｎ１＝１．７５、ｎ３＝１．５）の構造に等しくなり、よく知られた位相形回折格子の原理（例えば前出「光学の原理」参照）に従って光を回折する。回折角は、液晶１０６と光または熱硬化型高分子材料１０５の間隔が狭いほど大きく、高分子材料１０５と液晶１０６の界面と入射光とがなす角度を回折光が中心に向くように設定してあるため、入射光１０８および１０９は大きく回折し入射光１１０は直進し、回折光を集光することができた。

【００１２】また、図１（ｂ）に示すように透明電極１０３と透明電極１０４との間に電源１０７により電圧を加え、液晶１０６の屈折率をｎ２にすると、屈折率がｎ３／ｎ２／ｎ３…ｎ３／ｎ２／ｎ３（ｎ２＝１．５２、ｎ３＝１．５）の構造となり、各領域の屈折率差がほとんどなくなり、このため光の回折がほとんどなく、光を直進させることができる。なお、ここではｎ１＝１．７５、ｎ２＝１．５２、ｎ３＝１．５の場合について示したが、これに限らず液晶の電圧を印加したときの屈折率または電圧を印加しないときの屈折率のいずれかが、高分子材料の屈折率に近ければよい。本実施例では、屈折率が変化する材料にネマティック液晶を用いたが、その限りではなく、電圧によって屈折率が変化する高分子液晶や強誘電性液晶であってもよい。また、高分子材料の原料としてエポキシ樹脂またはラックストラックＬＡＯ２０８を用いたが、これに限ることなく、光または熱で硬化する高分子材料を用いればよい。

【００１３】

第２実施例、第３実施例、第４実施例、第５実施例

上記第１実施例の光学素子は回折光を集光する機能を有するが、液晶と高分子材料との配置によって様々な光学機能を具備させることが可能であり、例えば回折光を分散させる光学素子の第２実施例を図２に示す。本実施例は上記第１実施例と同様に、高分子材料２０５と液晶２０６の界面と入射光とがなす角度を変えている。図３に示す第３実施例は、回折光を複数の領域で集光できる光学素子である。また、図４に示す第４実施例は回折光を複数の領域で分散できる光学素子であり、図５に示す第５実施例は回折光の集光位置が素子の中央部からずれている光学素子である。上記それぞれの光学素子では、液晶と高分子材料との２つの領域が周期的に分離したものを示したが、上記実施例に限らず屈折率が周期的に変化

していればよい。このため、上記光学素子は、図６（ａ）に示すように高分子材料３０５の内部に液晶ドロップレット３０６が周期的に分布して屈折率分布を生じさせてもよく、また図６（ｂ）に示すように液晶ドロップレットが不均一に形成されていても、屈折率分布が図１と同様に形成されていればよい。

【００１４】上記各光学素子の形成方法の概略を図７に示す。図７において（ａ）～（ｃ）はそれぞれの形成工程を示している。上記各光学素子の形成方法では、図７（ａ）に示すように、例えばガラス基板４０１、４０２上の膜厚５００ÅのＩＴＯ膜による２つの透明電極４０３と４０４との間に、例えばネマティック液晶（メルク社製：Ｅ－７）と光または熱硬化性樹脂（例えば熱硬化性樹脂：エポキシ樹脂、あるいは光硬化性樹脂：ラックストラックＬＡ０２０８）の混合液４０５を配し、図７（ｂ）に示すように、例えばアルゴンレーザによる波長４８８ｎｍの平行光４０６と収束光４０７とを照射した。このとき、上記アルゴンレーザによる平行光４０６と上記収束光４０７とは干渉を起こし、波面４０８の形状と波長４０９とを反映して、光に強弱を生じた干渉パタン４１０が得られた。上記干渉パタン４１０は、照射されたレーザ光４０６の強度、方向等の性質を反映して一義的に決るホログラムパタンである。すなわち、上記ホログラムパタンを屈折率変調として記録したホログラムは、照射されたレーザ光の強度や方向等の性質を再生できる（例えば大越孝敬著「ホログラフィ」電子通信学会編、１９９７年）。上記干渉パタン４１０が照射された光または熱硬化性樹脂と液晶との混合物４０５は、図７（ｃ）に示すように、光硬化性樹脂を含んでいる混合物の場合には光強度が強い領域で光硬化性樹脂が硬化した。また熱硬化性樹脂を含んだ混合物の場合には光強度が強い領域で発熱がおこり、上記熱硬化性樹脂が硬化した。このため、光が弱い領域には主に液晶が集り、結果として液晶４１２と高分子材料４１１とが分離された構造によるホログラムが作製できた。本発明の製造方法によれば、ホログラフィの原理にしたがい、レーザ光を照射するだけの工程で、波長間隔程度の微細間隔で液晶と高分子材料とを繰返し配置させることができ、かつ、レーザ光の光束を制御することにより、様々な光学特性を有する光学素子を簡便に作製することができる。このため、図２に示す第２実施例の光学素子を形成するためには図８（ａ）に示すレーザ照射方法により、図３に示す第３実施例の光学素子を形成するためには図８（ｂ）に示すレーザ照射方法により、また図５に示す第５実施例の光学素子を形成するためには図８（ｃ）に示すレーザ照射方法によって、それぞれ作製することができた。

【００１５】上記各実施例では液晶にネマティック液晶を用いたがその限りではなく、電圧によって屈折率または分子方向が変化する高分子液晶や強誘電性液晶であってもよい。また、干渉パタンを得るためにアルゴンレーザを用いたがその限りでなく、干渉光が得られ位相が揃った光源であればよい。さらにまた、熱硬化性樹脂にエポキシ樹脂、光硬化性樹脂にラックストラックＬＡ０２０８を用いたがこれに限ることはなく、光または熱で硬化する樹脂を用いればよい。

【００１６】第６実施例

つぎに本発明による光学素子の第６実施例として、集光した反射光を得るための光学素子とその動作原理を図９に示す。本光学素子の構造は、例えばガラス基板６０１、６０２上に形成した膜厚５００ÅのＩＴＯ膜による２つの透明電極６０３と６０４との間に、高分子材料（例えば熱硬化性樹脂：エポキシ樹脂、または光硬化性樹脂：ラックストラックＬＡ０２０８の硬化による高分子材料）６０５と、例えばネマティック液晶（例えばメルク社製Ｅ－７）６０６を凹面鏡のように湾曲させて積層している。

【００１７】上記光学素子では図９（ａ）に示すように、透明電極１０３と透明電極１０４との間に電圧を加えない場合には、上記液晶による領域６０６の屈折率をｎ１とすると、全体として屈折率がｎ３／ｎ１／ｎ３…ｎ３／ｎ１／ｎ３（ｎ１＝１．７５、ｎ３＝１．５）の多層構造に等しくなり、よく知られた多層構造の反射条件に従い（例えば、小山、西原著「光波電子光学」コロナ社、参照）、入射した光のうち特定波長の光だけがブラッグの反射条件を満たす角度で反射される。ここで、高分子材料６０５と液晶６０６とによる層は湾曲しているため、平行光を入射した場合に反射光を集光させることができる。また、図９（ｂ）に示すように透明電極６０３と透明電極６０４との間に電源６０７により電圧を加え、液晶による領域６０６の屈折率をｎ２とすると、屈折率がｎ３／ｎ２／ｎ３…ｎ３／ｎ２／ｎ３（ｎ２＝１．５２、ｎ３＝１．５）の構造となり、各領域の屈折率差がほとんどなくなる。このため、光の反射がほとんど起らなくなり光を直進させることができた。したがって、光の反射／直進が制御でき、反射光を集光させることができる光学素子を作製することができた。

【００１８】なお、ここではｎ１＝１．７５、ｎ２＝１．５２、ｎ３＝１．５の場合について示したがこれに限らず、液晶の電圧を印加したときの屈折率または電圧を印加しないときの屈折率のいずれかが、高分子材料の屈折率に近ければよい。本実施例では屈折率が変化する材料にネマティック液晶を用いたがその限りでなく、電圧によって屈折率が変化する高分子液晶や強誘電性液晶であってもよい。また、図９（ａ）に示す構成では光を集光する機能を有するが、液晶と光または熱硬化型高分子材料の配置を変えることによって、様々な光学機能を具備させることが可能なことは明らかである。つぎに種々の光学機能を備えた本発明による光学素子の実施例を示す。

【００１９】

第７実施例、第８実施例、第９実施例、第１０実施例
図１０に示す第７実施例は反射光を分散させる光学素子であり、図１１に示す第８実施例は複数の集光領域を有する光学素子であり、図１２に示す第９実施例は複数の分散領域を有する光学素子であり、図１３に示す第１０実施例は反射光の集光位置を光学素子の中央部からずらした光学素子である。また、上記各実施例では液晶と高分子材料の２つの領域が周期的に分離したものを示したが、これに限らず液晶ドロップレットの配置による屈折率が周期的に変化していればよい。

【００２０】図１４は上記各実施例の形成方法を示す概略図である。図１４（ａ）に示すように、例えばガラス基板８０１、８０２上に形成された膜厚５００ÅのＩＴＯ膜による２つの透明電極８０３と８０４との間に、例えばネマティック液晶（メルク社製：Ｅ－７）と光または熱硬化性樹脂（例えば熱硬化性樹脂：エポキシ樹脂あるいは光硬化性樹脂：ラックストラックＬＡ０２０８）の混合液８０５を配した。これに図１４（ｂ）に示すように、例えばアルゴンレーザによる波長４８８ｎｍの平行光８０７と収束光８０６とを照射した。このとき、上記アルゴンレーザによる平行光８０７と収束光８０６とは、波面８０８の形状と波長８０９とに対応して干渉を起し、光に強弱を有する干渉パタン８１０が得られた。上記干渉パタン８１０は、照射されたレーザ光の強度や方向等の性質を反映して一義的に決るホログラムパタンである（例えば大越孝敬著「ホログラフィ」電子通信学会編、１９７７年）。上記干渉パタン８１０が照射された光硬化樹脂と液晶との混合物８０５は、図１４（ｃ）に示すように光硬化性樹脂を含んでいる混合物の場合は、光強度が強い領域で光硬化型高分子材料が硬化した。また、熱硬化性樹脂を含んだ混合物の場合には、光強度が強い領域で発熱がおこり熱硬化型高分子材料が硬化した。このため、光が弱い領域には主に液晶が集まり、この結果、高分子材料８１１と液晶８１２とに分離された構造を作製できた。上記作製方法によると、レーザ光を照射するだけの工程で液晶と高分子材料とを繰返し配置させることができ、かつ、ホログラフィの原理に従いレーザ光を制御することによって、様々な光学特性を有する光学素子を簡便に作製することができる。このため、図１０に示す第７実施例の光学素子を形成するには図１５（ａ）に示す方法でレーザ光を照射し、図１１に示す第８実施例の光学素子を形成するには図１５（ｂ）に示す方法でレーザ光を照射し、図１３に示す第１０実施例の光学素子を形成するには図１５（ｃ）に示す方法でレーザ光を照射することにより、それぞれ作製することができた。

【００２１】第１１実施例
本発明による光学素子の第１１実施例を図１６に示す。本光学素子は同一領域に２種類の液晶と高分子からなる回折格子構造を有し、１つの回折格子は光を分散させ他の１つの回折格子は光を集光する。このため、入射光は複数方向に分離して放射されることになる。図１７は上記光学素子の形成方法を示す図である。液晶と光硬化性樹脂の混合液２０５Ａに平行なレーザ光と集光されたレーザ光と拡大されたレーザ光を照射する。このとき、レーザ光の光束に対応してレーザ光の干渉がおこり、干渉パタンに対応して光硬化性樹脂が硬化するため液晶と高分子材料とが分離し、上記図１６に示すような光学素子が形成できた。

【００２２】第１２実施例
本発明による光学素子の第１２実施例を図１８に示す。本光学素子は同一領域に２種類の液晶と高分子からなる多層構造を有し、１つの多層構造は光を分散反射させ他の１つの多層構造は光を集光反射する。このため、入射光は複数方向に分離して反射される。図１９は上記光学素子の形成方法を示す図である。液晶と光硬化性樹脂の混合液４０５Ａに平行なレーザ光と集光されたレーザ光と拡大されたレーザ光を照射している。このとき、レーザ光の光束に対応してレーザ光の干渉がおこり、干渉パタンに対応して光硬化性樹脂が硬化するため液晶と高分子材料とが分離し、上記図１８に示すような光学素子が形成できた。

【００２３】第１３実施例
本発明による光学素子の第１３実施例を図２０に示す。本光学素子は同一領域に回折格子構造と多層構造とを有し、回折光と反射光とを得ることができる。図２１は上記光学素子の形成方法を示す図である。液晶と光硬化性樹脂の混合液６０５Ａに３光束レーザ光を照射している。このとき、レーザ光の光束に対応してレーザ光の干渉がおこり、干渉パタンに対応して光硬化性樹脂が硬化することにより液晶と高分子材料とが分離し、上記光学素子が形成できた。

【００２４】なお、上記各実施例では、同一領域に２種類の多層構造あるいは回折格子構造を形成した光学素子について示したが、さらに多くの多層構造や回折格子構造を含んでいてもよく、この場合、さらに多くの方向へ光が回折、反射することになる。また、上記のような素子は、さらに多くのレーザ光を使用することによって容易に作製することができる。

【００２５】第１４実施例
本発明による光学素子を複数平面配置した光学装置の例を図２２に示す。図２２において、７０１Ａは例えば透明なガラス基板、７０２Ａはマトリクス状に配置された透明電極、７０３Ａは液晶と高分子材料との複合体である。上記光学装置によれば、複数の入射光に対し、各光学素子により独立に光の回折もしくは反射を制御することができる。

【００２６】第１５実施例、第１６実施例
図２３に示す第１５実施例は上記第１４実施例と同様の構成であるが、駆動には例えば薄膜トランジスタまたは

薄膜ダイオードなどの能動素子８０４Ａを設けて、各光学素子をそれぞれ駆動している。図２４に示す第１６実施例は、本発明による光学素子を複数積層して使用した光学装置の例を示す図であり、本光学装置では回折および反射の機能を増加させることができる。

【００２７】上記各実施例では、液晶にネマティック液晶を用いたが、その限りでなく、電圧によって屈折率または分子方向が変化する高分子液晶や強誘電性液晶であってもよい。また、干渉パタンを得るためにアルゴンレーザを用いたが、その限りでなく、干渉光が得られる位相が揃った光源であればよい。また、熱硬化性樹脂にエポキシ樹脂、光硬化性樹脂にラックストラックＬＡ０２０８を用いたが、これに限ることなく、光または熱で硬化する高分子材料を用いればよい。

【００２８】

【発明の効果】上記のように本発明による光学素子は、液晶と高分子材料とからなり屈折率が異なる複数の領域を有し、電界により上記液晶の屈折率を変化させ、入射光の回折／直進または反射／直進を制御可能にした光学素子において、上記回折光または反射光が入射平行光に対し収束または分散するように、上記液晶領域と上記高分子領域とを平面的または立体的に配置したことにより、光の回折／直進または反射／直進が制御可能で、かつ上記回折光および反射光を集光または分散するように、レンズ等の光学素子の機能を有し、このため、回折光および反射光を集光、分散させるためのレンズ等の光学素子を別途に設ける必要がなく、光学装置の構成を簡単にすることができる。また、本発明の光学素子形成方法によれば、本発明の各種光学素子を、レーザ光を照射するだけの工程で極めて簡単に作製することができる。

【図面の簡単な説明】

【図１】本発明による光学素子の第１実施例として集光した回折光を得る素子を示す図で、（ａ）は透明電極間に電圧を加えない状態を示す図、（ｂ）は透明電極間に電圧を加えた状態を示す図である。

【図２】本発明の第２実施例を示す図である。

【図３】本発明の第３実施例を示す図である。

【図４】本発明の第４実施例を示す図である。

【図５】本発明の第５実施例を示す図である。

【図６】高分子材料内部に液晶ドロップレットがある光学素子を示す図で、（ａ）は液晶ドロップレットが周期的に分布している光学素子図、（ｂ）は液晶ドロップレットが不均一に形成されている光学素子図である。

【図７】上記各実施例の形成方法を示す図で、（ａ）～（ｃ）はそれぞれの製造工程を示す図である。

【図８】上記製造工程におけるレーザ照射方法をそれぞれ（ａ）、（ｂ）、（ｃ）に示す図である。

【図９】本発明の第６実施例として集光した反射光を得る光学素子を示す図で、（ａ）は透明電極間に電圧を加えない状態を示す図、（ｂ）は透明電極間に電圧を加えた状態を示す図である。

【図１０】本発明の第７実施例を示す図である。

【図１１】本発明の第８実施例を示す図である。

【図１２】本発明の第９実施例を示す図である。

【図１３】本発明の第１０実施例を示す図である。

【図１４】上記各実施例の形成方法を示す図で、（ａ）～（ｃ）はそれぞれの製造工程を示す図である。

【図１５】上記製造工程におけるレーザ照射方法をそれぞれ（ａ）、（ｂ）、（ｃ）に示す図である。

【図１６】本発明の第１１実施例として、２種類の液晶と高分子からなる回折格子を同一領域に有する光学素子を示す図である。

【図１７】上記実施例の形成方法を示す図である。

【図１８】本発明の第１２実施例として、２種類の液晶と高分子からなる多層構造回折格子を同一領域に有する光学素子を示す図である。

【図１９】上記実施例の形成方法を示す図である。

【図２０】本発明の第１３実施例として、回折格子構造と多層構造とを同一領域に有する光学素子を示す図である。

【図２１】上記実施例の形成方法を示す図である。

【図２２】本発明の第１４実施例として、上記光学素子を複数平面配置した光学装置を示す図である。

【図２３】本発明の第１５実施例として、上記光学素子を複数平面配置した光学装置の他の例を示す図である。

【図２４】本発明の第１６実施例として、上記光学素子を複数積層使用した光学装置を示す図である。

【図２５】従来の光の回折／直進を制御する光学素子を示す図である。

【図２６】従来の光の反射／直進を制御する光学素子を示す図である。

【符号の説明】

１０５、２０５、４１１、６０５、７０５、８１１、１０５Ａ、２０５Ａ、３０５Ａ、５０５Ａ　高分子材料

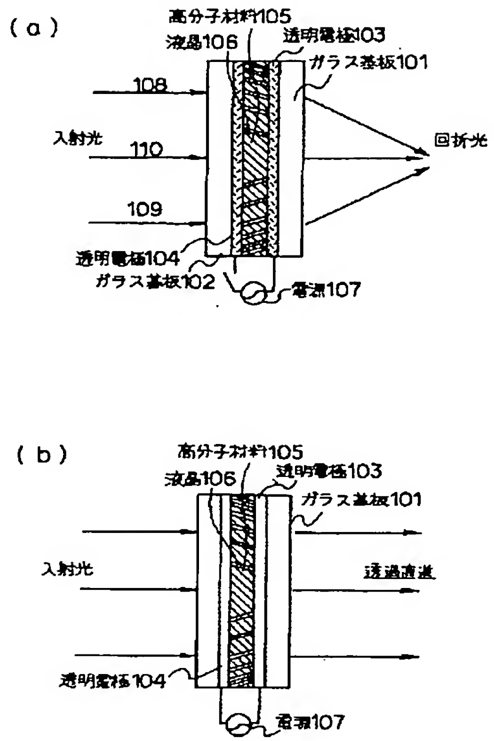
１０６、２０６、４１２、６０６、７０６、８１２、１０６Ａ、３０６Ａ、５０６Ａ　液晶

１０７、６０７、１０７Ａ、３０７Ａ、５０７Ａ　電源

４０５、５０５、８０５、９０５、４０５Ａ、６０５Ａ　熱または光硬化性樹脂と液晶との混合物

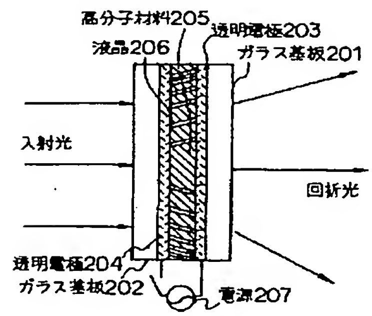
【図1】

図1



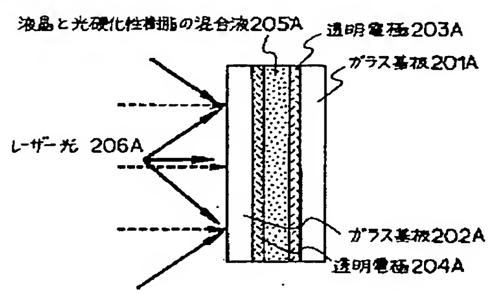
【図2】

図2



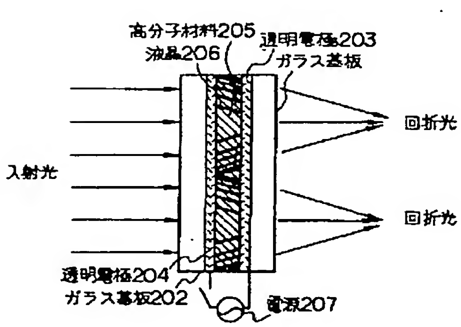
【図17】

図17



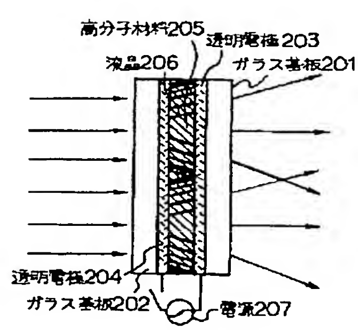
【図3】

図3



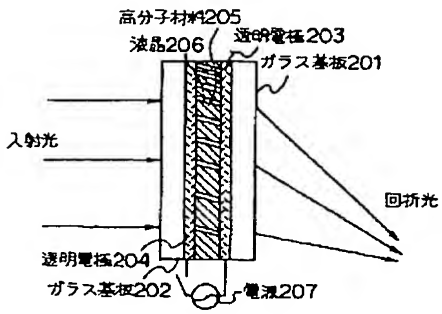
【図4】

図4



【図５】

図5

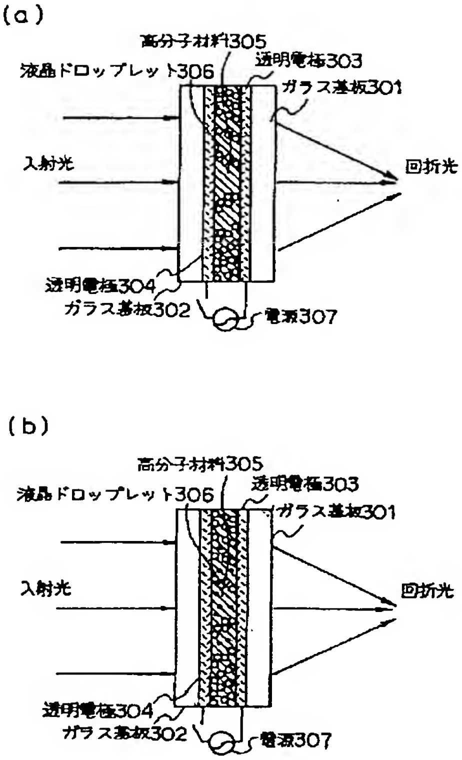


【図６】

図6

(a)

(b)



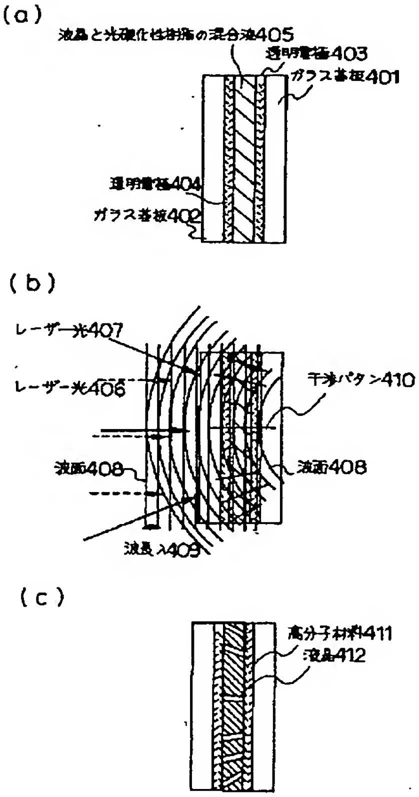
【図７】

図7

(a)

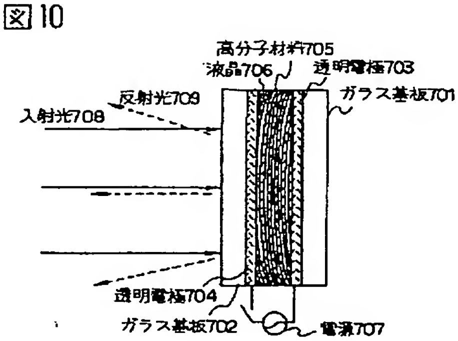
(b)

(c)



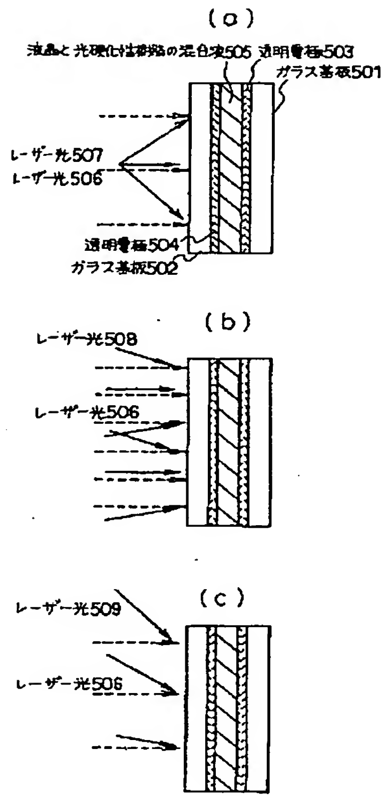
【図１０】

図10



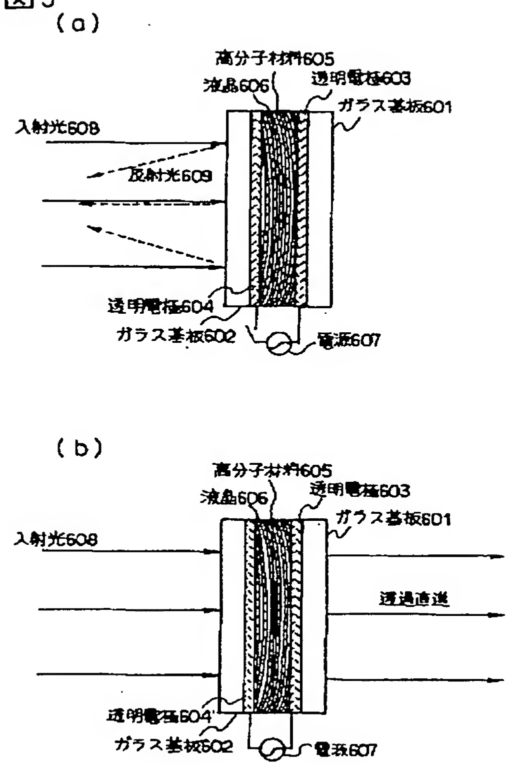
【図８】

図8



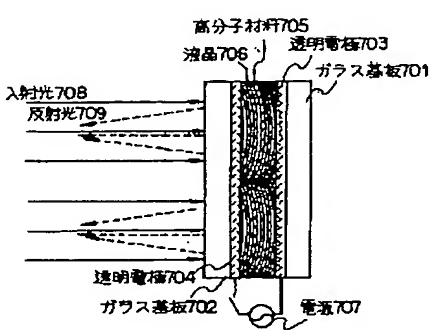
【図９】

図9



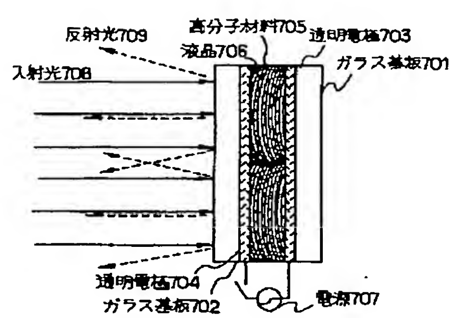
【図１１】

図11



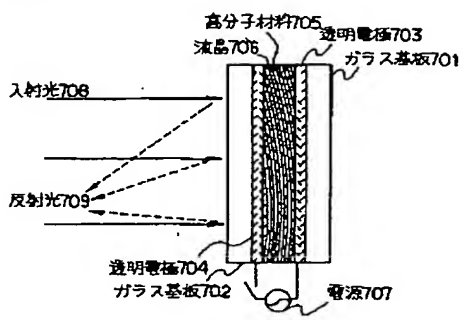
【図１２】

図12



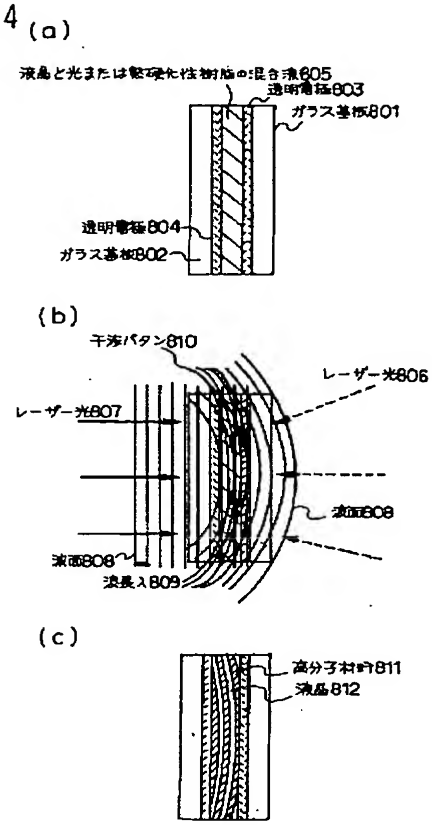
【図１３】

図13



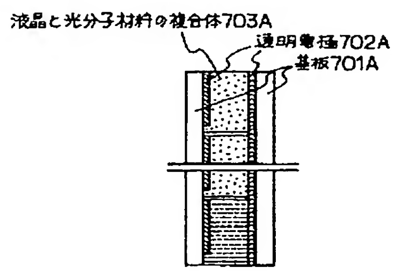
【図１４】

図14



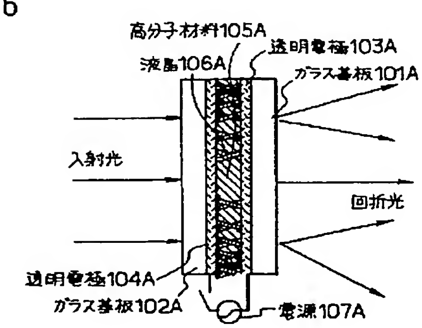
【図２２】

図22



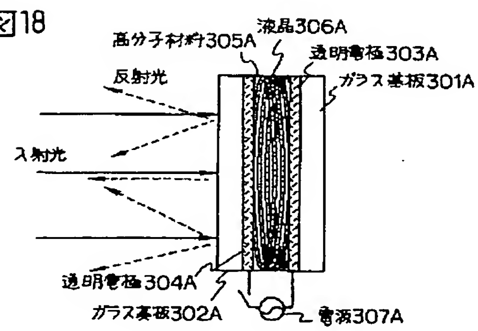
【図１６】

図16



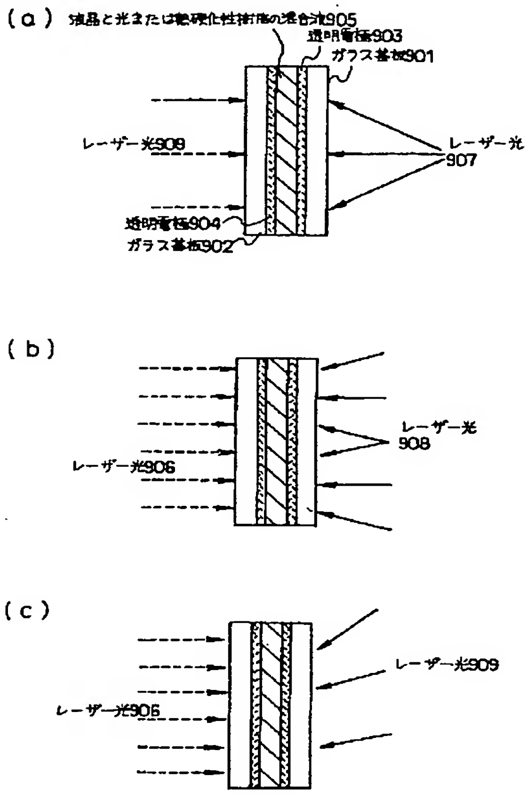
【図１８】

図18



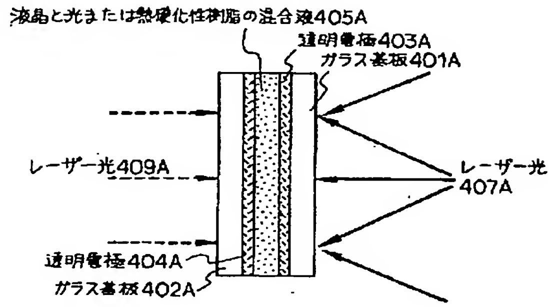
【図１５】

図15



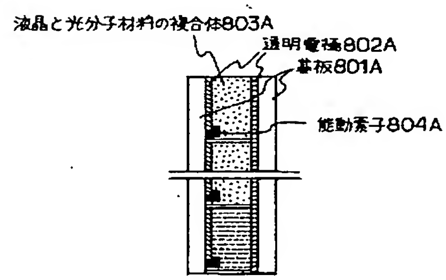
【図１９】

図19



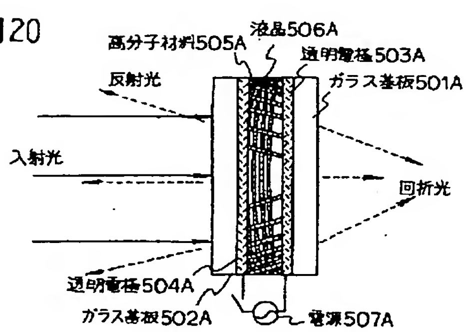
【図２３】

図23



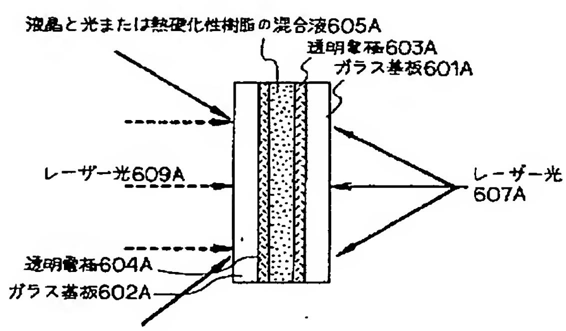
【図２０】

図20



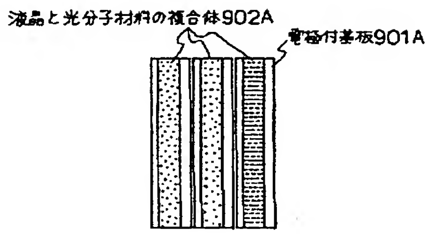
【図２１】

図21



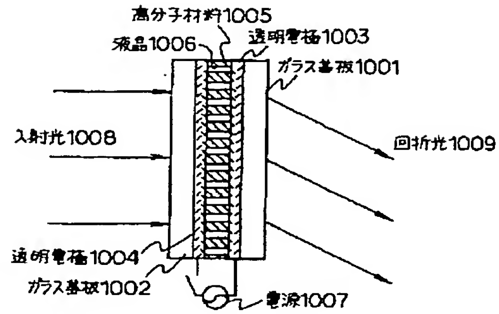
【図２４】

図24



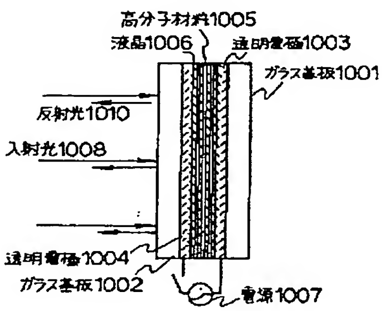
【図２５】

図25



【図２６】

図26



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PATENT ABSTRACTS OF JAPAN

(11)Publication number : 06-308471
(43)Date of publication of application : 04.11.1994

(51)Int.Cl. G02F 1/1333
G02F 1/13
G02F 1/13

(21)Application number : 05-296287
(22)Date of filing : 26.11.1993

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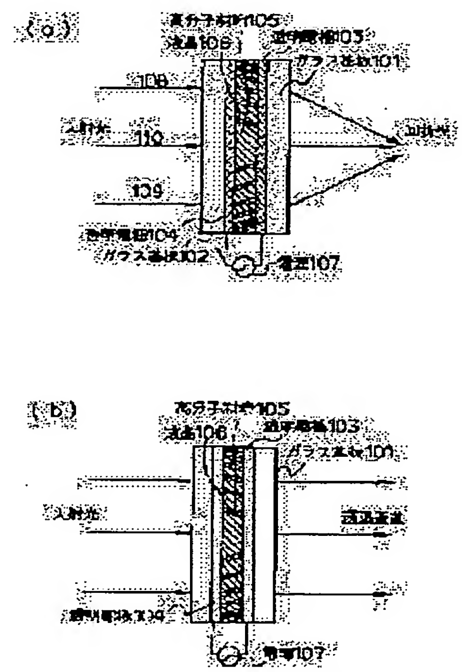
(30)Priority
Priority number : 05 33221 Priority date : 23.02.1993 Priority country : JP

(54) OPTICAL ELEMENT AND ITS PRODUCTION

(57)Abstract:
PURPOSE: To enable the control of diffraction/rectilinear advance or reflection/ rectilinear advance of light by flatly or three-dimensionally arranging liquid crystal regions and high-polymer regions in such a manner that diffracted light or reflected light converges or disperses with incident collimated beams of light.
CONSTITUTION: For example, the regions 105 consisting of a photo or thermosetting type high-polymer material having a refractive index n3 and nematic liquid crystals 106 variable in refractive index from n1 to n2 by electric fields are arranged at varied intervals between two transparent electrodes 103, 104 consisting of ITO films formed on glass substrates 101, 102. The element is provided with a power source 107 for changing the refractive index of the nematic liquid crystals 106. The element has the structure of the diffraction grating arranged alternately with the high-polymer materials 105 and the liquid crystals 106 and arranged therewith in such a manner that the periods of the high-polymer materials 105 and the liquid crystals 106 are longer the nearer the central part. The liquid crystal regions 106 and the high-polymer regions 105 are flatly or three-dimensionally arranged in such a manner that the diffracted light or reflected light converges or disperses with the incident collimated beams of light.



LEGAL STATUS

[Date of request for examination]	26.10.1999
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3162235
[Date of registration]	23.02.2001
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

CLAIMS

[Claim(s)]

[Claim 1] The optical element characterized by to have arranged the above-mentioned liquid-crystal field and the above-mentioned macromolecule field superficially or in three dimensions so that may have two or more fields where it consists of liquid crystal and polymeric materials, and refractive indexes differ, the refractive index of the above-mentioned liquid crystal may be changed by electric field, it may set to the optical element which made controllable diffraction / rectilinear propagation of incident light, or reflection/rectilinear propagation and the above-mentioned diffracted light or the reflected light may complete or distribute to incidence parallel light.

[Claim 2] In the manufacture approach of the optical element which it has two or more fields where it consists of liquid crystal and polymeric materials, and refractive indexes differ, and the refractive index of the above-mentioned liquid crystal was changed by electric field, and made controllable diffraction / rectilinear propagation of incident light, or reflection/rectilinear propagation Use light or thermosetting resin for the above-mentioned polymeric materials, irradiate the laser beam which controlled two or more flux of lights at mixture with the above-mentioned liquid crystal, light, or thermosetting resin, and the strength layer of the light by the interference pattern of laser separates liquid crystal and polymeric materials. The manufacture approach of the optical element characterized by arranging the field of the above-mentioned liquid crystal, and the field of the above-mentioned polymeric materials.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the optical element to which the diffracted light [as opposed to / it is electrically controllable and / incidence parallel light] and the reflected light converge or distribute diffraction / rectilinear propagation of light, or reflection/rectilinear propagation, and its manufacture approach.
[0002]
[Description of the Prior Art] We invented the optical element which can control diffraction / rectilinear propagation of light, or reflection/rectilinear propagation by the electrical potential difference (Japanese Patent Application No. No. 295617 [three to], and Japanese Patent Application No. No. 341531 [three to]). The structure of the optical element which controls diffraction/rectilinear propagation of light is shown in drawing 25 , and the structure of the optical element which controls reflection/rectilinear propagation of light is shown in drawing 26 . These optical elements form the periodic structure which consists of a field of polymeric materials 1005, and a field of liquid crystal 1006 among transparent electrodes 1003 and 1004. Since a refractive index changes with electric fields, liquid crystal can change the refractive-index difference of liquid crystal and polymeric materials. In drawing 25 , when the refractive-index difference of liquid crystal and polymeric materials is large, light is diffracted according to the principle (see "the principle of optics", Born, WORUFU work, and the Tokai University publication) of a phase form diffraction grating. Moreover, if an electrical potential difference is impressed, the refractive index of liquid crystal is changed and the refractive-index difference of polymeric materials and liquid crystal is made small, the structure of a diffraction grating can disappear and light can be made to go straight on as it is. Therefore, diffraction/rectilinear propagation of light are controllable. On the other hand, in drawing 26 , when the refractive-index difference of liquid crystal and polymeric materials is large, the light of specific wavelength is reflected from the optical property of multilayers. Moreover, if an electrical potential difference is impressed, the refractive index of liquid crystal is changed and the refractive-index difference of polymeric materials and liquid crystal is made small, the above-mentioned multilayer structure can disappear and light can be made to go straight on as it is. Therefore, reflection/rectilinear propagation of light are controllable.
[0003]
[Problem(s) to be Solved by the Invention] However, it was what sets to the above-mentioned optical element, and is diffracted and reflected by making parallel incident light into parallel light. For this reason, in order to converge or distribute the diffracted light and the reflected light, optical elements, such as a lens, needed to be prepared separately, and in order to have applied to the optical equipment which needs convergence or distribution of light, there was a problem that a configuration became complicated.
[0004] Diffraction / rectilinear propagation, or this invention's reflection/rectilinear propagation is electrically controllable, and further, it aims at obtaining the optical element equipped with optical element functions, such as a lens, so that the diffracted light and the reflected light to incidence parallel light may complete or distribute.
[0005]
[Means for Solving the Problem] The above-mentioned purpose has two or more fields where the refractive indexes which consist of liquid crystal and polymeric materials differ, changes the refractive index of the above-mentioned liquid crystal by electric field, sets to the optical element which made controllable diffraction / rectilinear propagation of incident light, or reflection/rectilinear propagation, and it is attained by arranging the above-mentioned liquid-crystal field and the above-mentioned macromolecule field superficially or in three dimensions so that the above-mentioned diffracted light or the reflected light may complete or distribute to incidence parallel light.
[0006] Moreover, light or thermosetting resin is used for the above-mentioned polymeric materials, the laser beam which controlled two or more light is irradiated at mixture with the above-mentioned liquid crystal, light, or thermosetting resin, and it can attain by separating liquid crystal and polymeric materials, arranging each field, and manufacturing the above-mentioned optical element by the strength layer of the light by the interference pattern of laser.
[0007]
[Function] The optical element of this invention changes the refractive index of liquid crystal by electric field, it can control diffraction / rectilinear propagation of light, or reflection/rectilinear propagation, and it can give the function as an optical element which controls the flux of light of light like a lens so that the above-mentioned diffracted light or the reflected light may be converged or distributed. For this reason, it is not necessary to prepare optical elements, such as a lens, separately, and the configuration of optical equipment becomes easy.
[0008] Moreover, in order to arrange the field of liquid crystal, and the field of polymeric materials so that the diffracted light or the reflected light may complete or distribute, light or thermosetting resin is used as a raw material of the above-mentioned polymeric materials, the laser beam which controlled two or more flux of lights is irradiated at mixture with the above-mentioned liquid crystal, light, or thermosetting resin, and the strength layer of the light by the interference pattern of laser separates the above-mentioned liquid crystal and the above-mentioned polymeric materials. If the above-mentioned technique is used, since the flux of light of a laser beam will be recorded as an interference pattern, according to the principle (see for example, "holography" Ogoshi ******, edited by Institute of Electronics and Communication Engineers, and 1977) of holography, the irradiated flux of light of a laser beam is reproducible. That is, by controlling the flux of light of the laser beam which irradiates at the time of optical element production, various diffracted-light bundles and a reflected light bundle can be reproduced, and a controllable optical element can be electrically formed for the above-mentioned diffracted light and the reflected light. Moreover, the above-mentioned optical element is producible by the very easy production approach of only laser radiation.
[0009]
[Example] The example of this invention is explained with a drawing below. Drawing showing an optical element for drawing 1 to obtain

the diffracted light by this invention which condensed, Drawing showing the optical element which drawing 2 makes distribute the diffracted light, drawing showing the optical element to which drawing 3 can condense the diffracted light in two or more fields, Drawing showing the optical element to which drawing 4 can distribute the diffracted light in two or more fields, drawing showing the optical element from which the condensing location of the diffracted light has shifted [center section / of the component], as for drawing 5 , and drawing 6 are the optical elements by which liquid crystal drop let is formed in the interior of polymeric materials. Drawing showing the component over which (a) is distributed periodically, and the component by which (b) is formed in the ununiformity, Drawing showing the formation approach of an optical element of obtaining the diffracted light in which drawing 7 carried out [above-mentioned] condensing, drawing showing the laser radiation approach of as opposed to the above-mentioned optical element in drawing 8 , Drawing showing an optical element for drawing 9 to obtain the reflected light by this invention which condensed, Drawing showing the optical element which drawing 10 makes distribute the reflected light, drawing showing the optical element in which drawing 11 has two or more condensing fields, Drawing showing the optical element in which drawing 12 has two or more distributed fields, drawing showing the optical element to which drawing 13 was able to shift the condensing location of the reflected light from the optical element center section, Drawing showing the formation approach of an optical element of obtaining the reflected light in which drawing 14 carried out [above-mentioned] condensing, drawing showing the laser radiation approach of as opposed to the above-mentioned optical element in drawing 15 , Drawing showing the optical element which has the diffraction grating which drawing 16 becomes from two kinds of liquid crystal, and a macromolecule to the same field, Drawing in which drawing 17 shows the formation approach of the above-mentioned optical element, drawing showing the optical element which has the diffraction grating of the multilayer structure which drawing 18 becomes from two kinds of liquid crystal, and a macromolecule to the same field, Drawing in which drawing 19 shows the formation approach of the above-mentioned optical element, drawing showing the optical element to which drawing 20 has diffraction-grating structure and multilayer structure to the same field, Drawing in which drawing 21 shows the formation approach of the above-mentioned optical element, drawing showing the optical equipment with which drawing 22 carried out two or more plane configuration of the optical element of this invention, drawing showing other optical equipments with which drawing 23 carried out two or more plane configuration of the optical element of this invention, and drawing 24 are drawings showing the optical equipment which carried out two or more laminatings use of the optical element of this invention.

[0010] The optical element and the principle of operation for obtaining the diffracted light which condensed as the 1st example of the optical element by 1st example this invention are shown in drawing 1 . As the optical element of this example is shown in drawing 1 (a), between two transparent electrodes 103 and 104 by the ITO film of 500A of thickness formed on a glass substrate 101 and 102 The field 105 by the light or heat-curing mold polymeric materials (for example, thermosetting resin: polymeric materials which the epoxy resin (n3=1.5) or photo-setting resin:Lux truck LA 0208 (n3=1.5) hardened) of a refractive index n3, By electric field, from n1 to n2, the refractive index changed spacing and has arranged the field 106 by the strange good pneumatic liquid crystal (for example, E[by Merck Co.]- 7:n 1= 1.75, n 2= 1.52). Moreover, 107 is a power source for changing the refractive index of the above-mentioned pneumatic liquid crystal 106.

[0011] In the above-mentioned optical element, polymeric materials 105 and liquid crystal 106 are arranged by turns, and it has the structure of the diffraction grating arranged so that the period of polymeric materials 105 and liquid crystal 106 may become long, so that it becomes a core. Moreover, the include angle which the above-mentioned polymeric materials 106, the interface of the above-mentioned liquid crystal 105, and incident light make is set up so that the diffracted light may turn to the core of the optical element of this invention. If the above-mentioned optical element does not apply an electrical potential difference according to a power source 107 between a transparent electrode 103 and a transparent electrode 104 as shown in drawing 1 (a), when setting the refractive index of the field 106 by liquid crystal to n1, A refractive index is n3/n1/n3 as a whole. -- It becomes equal to the structure of n3/n1/n3 (n1=1.75, n3=1.5), and light is diffracted according to the principle (for example, refer to above "the principle of optics") of a phase form diffraction grating known well. The angle of diffraction was so large that spacing of liquid crystal 106, light, or the heat-curing mold polymeric materials 105 was narrow, since it had set up so that the diffracted light may turn [include angle / which polymeric materials 105, the interface of liquid crystal 106, and incident light make] to a core, it was able to diffract greatly, and incident light 110 was able to go straight on and incident light 108 and 109 was able to condense the diffracted light.

[0012] Moreover, if an electrical potential difference is applied according to a power source 107 between a transparent electrode 103 and a transparent electrode 104 as shown in drawing 1 (b), and the refractive index of liquid crystal 106 is set to n2 A refractive index is n3/n2/n3. -- It becomes the structure of n3/n2/n3 (n2=1.52, n3=1.5), and the refractive-index difference of each field is almost lost, for this reason, there is almost no diffraction of light, and light can be made to go straight on. In addition, although the case of n1=1.75, n2=1.52, and n3=1.5 was shown here, either of the refractive indexes when not impressing the refractive index or electrical potential difference when impressing the electrical potential difference of not only this but liquid crystal should be just close to the refractive index of polymeric materials. Although the pneumatic liquid crystal was used for the ingredient from which a refractive index changes in this example, you may be the polymer liquid crystal and ferroelectric liquid crystal from which a refractive index changes with the not a limitation but electrical potential differences. Moreover, what is necessary is just to use the polymeric materials hardened with light or heat, without restricting to this, although the epoxy resin or the Lux truck LA 0208 was used as a raw material of polymeric materials.

[0013]

Although the optical element of the 2nd example, the 3rd example, the 4th example, and the 1st example of the 5th example above has the function which condenses the diffracted light, it is possible to make various optical functions provide by arrangement with liquid crystal and polymeric materials, for example, the 2nd example of the optical element which distributes the diffracted light is shown in drawing 2 . This example is changing the include angle which polymeric materials 205, the interface of liquid crystal 206, and incident light make like the 1st example of the above. The 3rd example shown in drawing 3 is the optical element which can condense the diffracted light in two or more fields. Moreover, the 4th example shown in drawing 4 is the optical element which can distribute the diffracted light in two or more fields, and the 5th example shown in drawing 5 is an optical element from which the condensing location of the diffracted light has shifted [center section / of the component]. Although two fields of liquid crystal and polymeric materials showed what was separated periodically by the optical element of each above, not only the above-mentioned example but the refractive index should just be changing periodically. For this reason, as the liquid crystal drop let 306 is periodically distributed over the interior of polymeric materials 305, and refractive-index distribution is produced, as the above-mentioned optical element is shown in drawing 6 (a), and shown in drawing 6 (b), even if liquid crystal drop let is formed in the ununiformity, refractive-index distribution should just be formed like drawing 1 .

[0014] The outline of the formation approach of each above-mentioned optical element is shown in drawing 7 . In drawing 7 , (a) - (c) shows each formation process. By the formation approach of each above-mentioned optical element, as shown in drawing 7 (a), between two transparent electrodes 403 and 404 by the glass substrate 401 and the ITO film of 500A of thickness on 402 For example, as the mixed liquor 405 of a pneumatic liquid crystal (Merck [Co.] make: E-7), light, or thermosetting resin (for example, thermosetting resin: epoxy resin or photo-setting resin:Lux truck LA 0208) is allotted and it is shown in drawing 7 (b) For example, the parallel light

406 with a wavelength of 488nm and the convergence light 407 by argon laser were irradiated. At this time, as for the parallel light 406 and the above-mentioned convergence light 407 by the above-mentioned argon laser, the interference pattern 410 which produced strength in light reflecting a lifting, and the configuration and wavelength 409 of a wave front 408 was obtained in interference. The above-mentioned interference pattern 410 is a hologram pattern uniquely decided reflecting the property of the reinforcement of the irradiated laser beam 406, a direction, etc. That is, the hologram which recorded the above-mentioned hologram pattern as a refractive-index modulation can reproduce the irradiated property of the reinforcement of a laser beam, a direction, etc. (for example, the volume for Ogoshi ****** "holography" Institute of Electronics and Communication Engineers, 1997). As shown in drawing 7 (c), the photo-setting resin hardened the mixture 405 of the light or thermosetting resin with which the above-mentioned interference pattern 410 was irradiated, and liquid crystal in the field where optical reinforcement is strong in the case of the mixture containing a photo-setting resin. Moreover, in the case of the mixture containing thermosetting resin, generation of heat started in the field where optical reinforcement is strong, and the above-mentioned thermosetting resin hardened. For this reason, in the field where light is weak, the hologram by the structure where liquid crystal 412 and polymeric materials 411 were mainly separated for liquid crystal as an assembly and a result was producible. According to the manufacture approach of this invention, the optical element which has various optical properties is producible simple by being able to repeat and arrange liquid crystal and polymeric materials at intervals of [detailed] wavelength spacing extent, and controlling the flux of light of a laser beam only by the process which irradiates a laser beam according to the principle of holography. For this reason, it was producible, respectively by the laser radiation approach shown in drawing 8 (c) in order to form the optical element of the 5th example shown in drawing 5 again by the laser radiation approach shown in drawing 8 (b) in order to form the optical element of the 3rd example shown in drawing 3 by the laser radiation approach shown in drawing 8 (a) in order to form the optical element of the 2nd example shown in drawing 2 .

[0015] Although the pneumatic liquid crystal was used for liquid crystal in each above-mentioned example, you may be the polymer liquid crystal and ferroelectric liquid crystal from which a refractive index or the direction of a molecule changes with the not a limitation but electrical potential differences. Moreover, although argon laser was used in order to obtain an interference pattern, what is necessary is just the light source to which the not a limitation but interference light were acquired, and the phase was equal. What is necessary is just to use the resin which does not restrict to this and is hardened with light or heat further again, although the epoxy resin was used for thermosetting resin and the Lux truck LA 0208 was used for the photo-setting resin.

[0016] As the 6th example of the optical element by this invention, the optical element and the principle of operation for obtaining the reflected light which condensed are shown in drawing 9 below the 6th example. A pneumatic liquid crystal (for example, Merck Co. make E-7) 606 is incurvated like a concave mirror between two transparent electrodes 603 and 604 by the glass substrate 601 and the ITO film of 500A of thickness formed on 602, and the structure of this optical element is carrying out the laminating to polymeric materials (for example, thermosetting resin: polymeric materials by hardening of the epoxy resin or photo-setting resin:Lux truck LA 0208) 605 between.

[0017] As the above-mentioned optical element shows to drawing 9 (a), in not applying an electrical potential difference between a transparent electrode 103 and a transparent electrode 104 When the refractive index of the field 606 by the above-mentioned liquid crystal is set to n1, a refractive index is n3/n1/n3 as a whole. — It becomes equal to the multilayer structure of n3/n1/n3 (n1=1.75, n3=1.5). According to the reflective conditions of the multilayer structure known well (for example, Oyama, Nishihara work "light wave electron optics" Corona Publishing, reference), only the light of specific wavelength is reflected at the include angle which fulfills Bragg's reflective conditions among the light which carried out incidence. When incidence of the parallel light is carried out, it can make the reflected light condense here, since the layer by polymeric materials 605 and liquid crystal 606 is curving. Moreover, when an electrical potential difference is applied according to a power source 607 between a transparent electrode 603 and a transparent electrode 604 as shown in drawing 9 (b), and the refractive index of the field 606 by liquid crystal is set to n2, a refractive index is n3/n2/n3. — It becomes the structure of n3/n2/n3 (n2=1.52, n3=1.5), and the refractive-index difference of each field is almost lost. For this reason, it becomes impossible for reflection of light to almost have taken place, and it was able to make light go straight on. Therefore, reflection/rectilinear propagation of light could be controlled, and the optical element which can make the reflected light condense was able to be produced.

[0018] In addition, although the case of n1=1.75, n2=1.52, and n3=1.5 was shown here, either of the refractive indexes when not impressing the refractive index or electrical potential difference when impressing the electrical potential difference of not only this but liquid crystal should be just close to the refractive index of polymeric materials. In this example, although the pneumatic liquid crystal was used for the ingredient from which a refractive index changes, you may be the polymer liquid crystal and ferroelectric liquid crystal from which a refractive index changes with the not a limitation but electrical potential differences. Moreover, although it has the function which condenses light with the configuration shown in drawing 9 (a), it is clear by changing arrangement of liquid crystal, light, or heat-curing mold polymeric materials that it is possible to make various optical functions provide. The example of the optical element by this invention equipped with various optical functions next is shown.

[0019]

The 7th example, the 8th example, the 9th example, and the 7th example shown in 10th example drawing 10 are optical elements which distribute the reflected light, the 8th example shown in drawing 11 is an optical element which has two or more condensing fields, the 9th example shown in drawing 12 is an optical element which has two or more distributed fields, and the 10th example shown in drawing 13 is the optical element which shifted the condensing location of the reflected light from the center section of the optical element. Moreover, although two fields, liquid crystal and polymeric materials, showed what was separated periodically in each above-mentioned example, the refractive index by arrangement of not only this but liquid crystal drop let should just be changing periodically.

[0020] Drawing 14 is the schematic diagram showing the formation approach of each above-mentioned example. As shown in drawing 14 (a), the mixed liquor 805 of a pneumatic liquid crystal (Merck [Co.] make: E-7), light, or thermosetting resin (for example, thermosetting resin: an epoxy resin or photo-setting resin : the Lux truck LA 0208) was allotted between two transparent electrodes 803 and 804 by the glass substrate 801 and the ITO film of 500A of thickness formed on 802. As shown in this at drawing 14 (b), the parallel light 807 with a wavelength of 488nm and the convergence light 806 by argon laser were irradiated. At this time, the parallel light 807 and the convergence light 806 by the above-mentioned argon laser caused interference corresponding to the configuration and wavelength 809 of a wave front 808, and the interference pattern 810 which has strength in light was obtained. The above-mentioned interference pattern 810 is a hologram pattern uniquely decided reflecting the irradiated property of the reinforcement of a laser beam, a direction, etc. (for example, the volume for Ogoshi ****** "holography" Institute of Electronics and Communication Engineers, 1977). In the case of the mixture with which the mixture 805 of the photo-curing resin and liquid crystal with which the above-mentioned interference pattern 810 was irradiated contains the photo-setting resin as shown in drawing 14 (c), photo-curing mold polymeric materials hardened in the field where optical reinforcement is strong. Moreover, in the case of the mixture containing thermosetting resin, generation of heat started in the field where optical reinforcement is strong, and heat-curing mold polymeric materials hardened. For this reason, in the field where light is weak, the structure where liquid crystal was mainly divided into an

assembly, consequently polymeric materials 811 and liquid crystal 812 was producible. According to the above-mentioned production approach, the optical element which has various optical properties is producible simple by being able to repeat and arrange liquid crystal and polymeric materials only at the process which irradiates a laser beam, and controlling a laser beam according to the principle of holography. For this reason, it was producible, respectively by irradiating a laser beam by the approach shown at drawing 15 (a) for forming the optical element of the 7th example shown in drawing 10 , irradiating a laser beam by the approach shown at drawing 15 (b) for forming the optical element of the 8th example shown in drawing 11 , and irradiating a laser beam by the approach shown at drawing 15 (c) for forming the optical element of the 10th example shown in drawing 13 .

[0021] The 11th example of the optical element by 11th example this invention is shown in drawing 16 . This optical element has the diffraction-grating structure which becomes the same field from two kinds of liquid crystal, and a macromolecule, one diffraction grating distributes light, and other one diffraction grating condenses light. For this reason, incident light will be separated and emitted in the direction of plurality. Drawing 17 is drawing showing the formation approach of the above-mentioned optical element. Liquid crystal, a laser beam parallel to mixed liquor 205A of a photo-setting resin, the condensed laser beam, and the expanded laser beam are irradiated. At this time, interference of a laser beam started corresponding to the flux of light of a laser beam, in order that a photo-setting resin might harden corresponding to an interference pattern, liquid crystal and polymeric materials dissociated, and the optical element as shown in above-mentioned drawing 16 has been formed.

[0022] The 12th example of the optical element by 12th example this invention is shown in drawing 18 . This optical element has the multilayer structure which becomes the same field from two kinds of liquid crystal, and a macromolecule, one multilayer structure carries out distributed reflection of the light, and other one multilayer structure carries out condensing reflection of the light. For this reason, incident light is separated and reflected in the direction of plurality. Drawing 19 is drawing showing the formation approach of the above-mentioned optical element. Liquid crystal, the laser beam parallel to mixed liquor 405A of a photo-setting resin, the condensed laser beam, and the expanded laser beam are irradiated. At this time, interference of a laser beam started corresponding to the flux of light of a laser beam, in order that a photo-setting resin might harden corresponding to an interference pattern, liquid crystal and polymeric materials dissociated, and the optical element as shown in above-mentioned drawing 18 has been formed.

[0023] The 13th example of the optical element by 13th example this invention is shown in drawing 20 . This optical element has diffraction-grating structure and multilayer structure to the same field, and can obtain the diffracted light and the reflected light. Drawing 21 is drawing showing the formation approach of the above-mentioned optical element. 3 flux-of-light laser beam is irradiated at mixed liquor 605A of liquid crystal and a photo-setting resin. At this time, interference of a laser beam started corresponding to the flux of light of a laser beam, when a photo-setting resin hardened corresponding to an interference pattern, liquid crystal and polymeric materials dissociated and the above-mentioned optical element has been formed.

[0024] In addition, although each above-mentioned example showed the optical element in which two kinds of multilayer structure or diffraction-grating structure was formed to the same field, further much multilayer structure and diffraction-grating structure may be included, and light will diffract and reflect in much more directions in this case. Moreover, the above components are easily producible by using much more laser beams.

[0025] The example of the optical equipment which carried out two or more plane configuration of the optical element by 14th example this invention is shown in drawing 22 . In drawing 22 , the transparent electrode with which a glass substrate transparent, for example and 702A have been arranged for 701A in the shape of a matrix, and 703A are the complex of liquid crystal and polymeric materials. According to the above-mentioned optical equipment, diffraction or reflection of light is independently controllable by each optical element to two or more incident light.

[0026] Although the 15th example and the 15th example shown in 16th example drawing 23 are the same configurations as the 14th example of the above, active element 804A, such as a thin film transistor or a thin-film diode, is prepared in a drive, and each optical element is driven, respectively. The 16th example shown in drawing 24 is drawing showing the example of the optical equipment which used it, having carried out two or more laminatings of the optical element by this invention, and can make the function of diffraction and reflection increase with this optical equipment.

[0027] Although the pneumatic liquid crystal was used for liquid crystal in each above-mentioned example, you may be the polymer liquid crystal and ferroelectric liquid crystal from which a refractive index or the direction of a molecule changes with the not a limitation but electrical potential differences. Moreover, although argon laser was used in order to obtain an interference pattern, what is necessary is just the light source to which the phase from which the not a limitation but interference light are acquired was equal. Moreover, what is necessary is just to use the polymeric materials hardened with light or heat, without restricting to this, although the epoxy resin was used for thermosetting resin and the Lux truck LA 0208 was used for the photo-setting resin.

[0028]

[Effect of the Invention] In the optical element which it has two or more fields where the optical element by this invention consists of liquid crystal and polymeric materials as mentioned above, and refractive indexes differ, and the refractive index of the above-mentioned liquid crystal was changed by electric field, and made controllable diffraction / rectilinear propagation of incident light, or reflection/rectilinear propagation Diffraction / rectilinear propagation of light, or reflection/rectilinear propagation is controllable by having arranged the above-mentioned liquid crystal field and the above-mentioned macromolecule field superficially or in three dimensions so that the above-mentioned diffracted light or the reflected light may complete or distribute to incidence parallel light. And it has the function of optical elements, such as a lens, for this reason, it is not necessary to prepare separately optical elements, such as a lens for condensing and distributing the diffracted light and the reflected light, and the configuration of optical equipment can be simplified so that the above-mentioned diffracted light and the reflected light may be condensed or distributed. Moreover, according to the optical element formation approach of this invention, the various optical elements of this invention can be produced very easily only at the process which irradiates a laser beam.

[Translation done.]

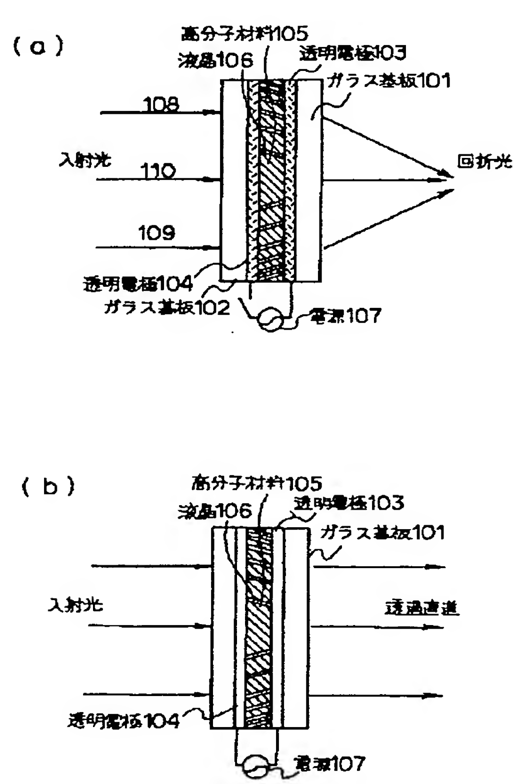
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the component which obtains the diffracted light which condensed as the 1st example of the optical element by this invention, and drawing showing the condition that (a) does not apply an electrical potential difference between transparent electrodes, and (b) are drawings showing the condition of having applied the electrical potential difference between transparent electrodes.
[Drawing 2] It is drawing showing the 2nd example of this invention.
[Drawing 3] It is drawing showing the 3rd example of this invention.
[Drawing 4] It is drawing showing the 4th example of this invention.
[Drawing 5] It is drawing showing the 5th example of this invention.
[Drawing 6] It is drawing showing the optical element which has liquid crystal drop let in the interior of polymeric materials, and, for (a), the optical element Fig. over which liquid crystal drop let is distributed periodically, and (b) are optical element Figs. where liquid crystal drop let is formed in the ununiformity.
[Drawing 7] It is drawing showing the formation approach of each above-mentioned example, and (a) - (c) is drawing showing each production process.
[Drawing 8] It is drawing showing the laser radiation approach in the above-mentioned production process in (a), (b), and (c), respectively.
[Drawing 9] It is drawing showing the optical element which obtains the reflected light which condensed as the 6th example of this invention, and drawing showing the condition that (a) does not apply an electrical potential difference between transparent electrodes, and (b) are drawings showing the condition of having applied the electrical potential difference between transparent electrodes.
[Drawing 10] It is drawing showing the 7th example of this invention.
[Drawing 11] It is drawing showing the 8th example of this invention.
[Drawing 12] It is drawing showing the 9th example of this invention.
[Drawing 13] It is drawing showing the 10th example of this invention.
[Drawing 14] It is drawing showing the formation approach of each above-mentioned example, and (a) - (c) is drawing showing each production process.
[Drawing 15] It is drawing showing the laser radiation approach in the above-mentioned production process in (a), (b), and (c), respectively.
[Drawing 16] It is drawing showing the optical element which has the diffraction grating which consists of two kinds of liquid crystal, and a macromolecule to the same field as the 11th example of this invention.
[Drawing 17] It is drawing showing the formation approach of the above-mentioned example.
[Drawing 18] It is drawing showing the optical element which has the multilayer-structure diffraction grating which consists of two kinds of liquid crystal, and a macromolecule to the same field as the 12th example of this invention.
[Drawing 19] It is drawing showing the formation approach of the above-mentioned example.
[Drawing 20] It is drawing showing the optical element which has diffraction-grating structure and multilayer structure to the same field as the 13th example of this invention.
[Drawing 21] It is drawing showing the formation approach of the above-mentioned example.
[Drawing 22] It is drawing showing the optical equipment which carried out two or more plane configuration of the above-mentioned optical element as the 14th example of this invention.
[Drawing 23] It is drawing showing other examples of the optical equipment which carried out two or more plane configuration of the above-mentioned optical element as the 15th example of this invention.
[Drawing 24] It is drawing showing the optical equipment which carried out two or more laminatings use of the above-mentioned optical element as the 16th example of this invention.
[Drawing 25] It is drawing showing the optical element which controls diffraction/rectilinear propagation of the conventional light.
[Drawing 26] It is drawing showing the optical element which controls reflection/rectilinear propagation of the conventional light.
[Description of Notations]
105, 205, 411, 605, 705, 811, 105A, 205A, 305A, 505A Polymeric materials
106, 206, 412, 606, 706, 812, 106A, 306A, 506A Liquid crystal
107, 607, 107A, 307A, 507A Power source
405, 505, 805, 905, 405A, 605A
Mixture of heat or a photo-setting resin, and liquid crystal

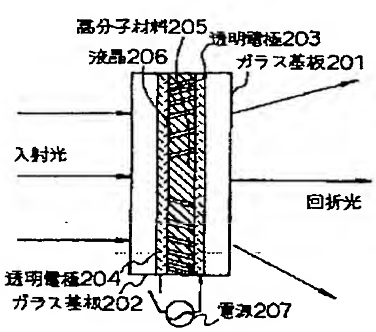
[Translation done.]

DRAWINGS

[Drawing 1]
図1

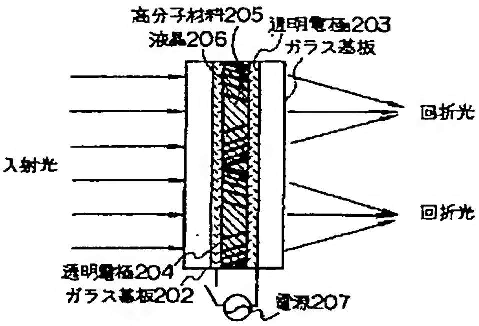


[Drawing 2]
図2



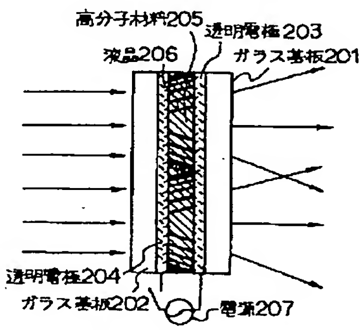
[Drawing 3]

図3



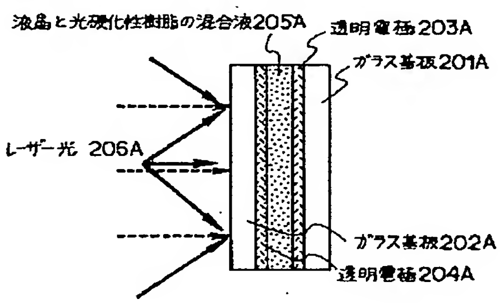
[Drawing 4]

図4



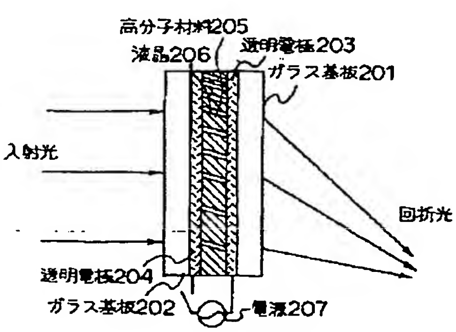
[Drawing 17]

図17



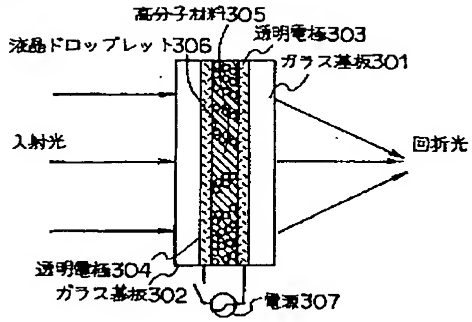
[Drawing 5]

図5

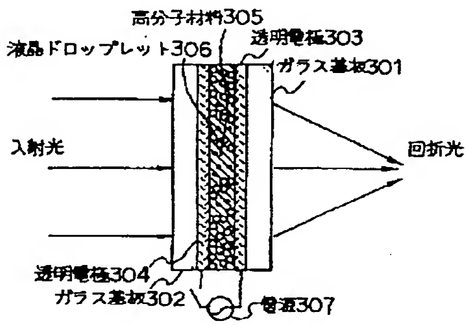


[Drawing 6]

図6
(a)

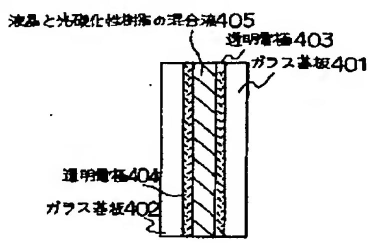


(b)

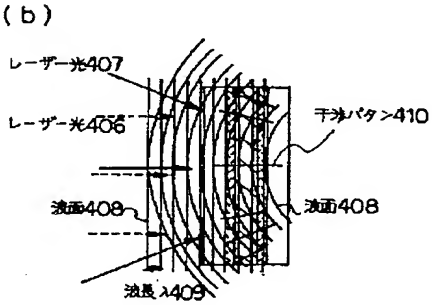


[Drawing 7]

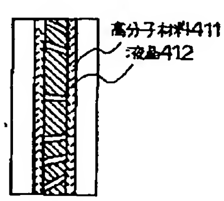
図7
(a)



(b)

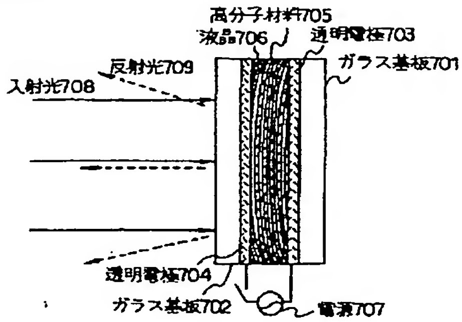


(c)



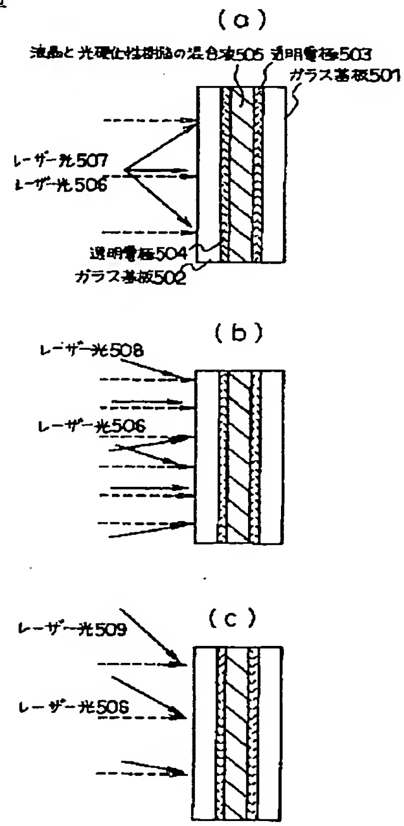
[Drawing 10]

図10



[Drawing 8]

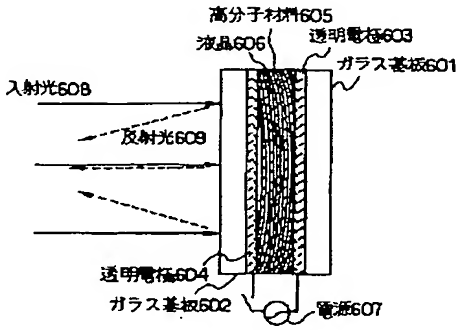
図8



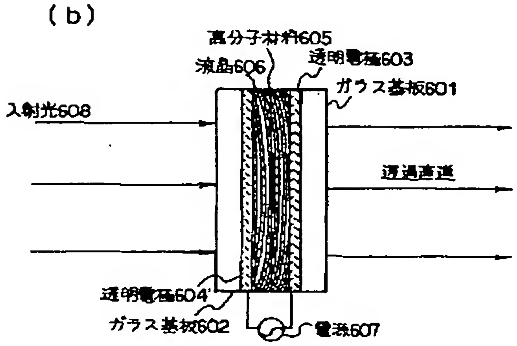
[Drawing 9]

図9

(a)

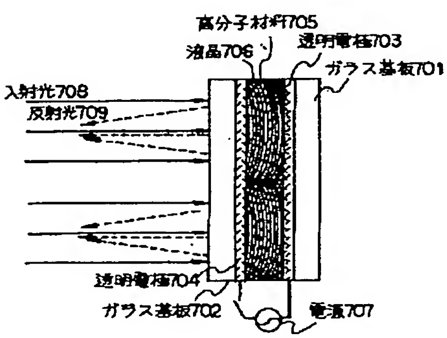


(b)



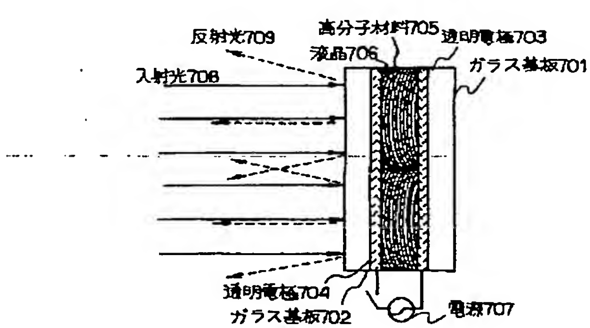
[Drawing 11]

図11



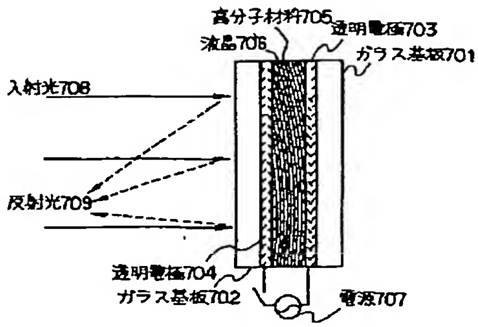
[Drawing 12]

図12



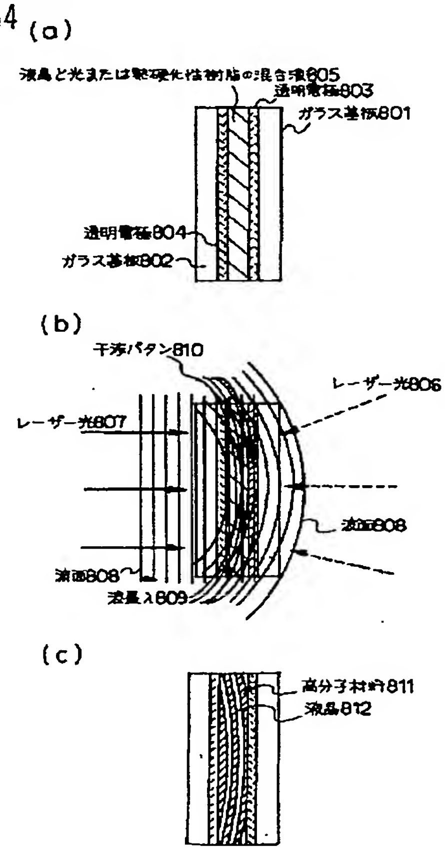
[Drawing 13]

図13



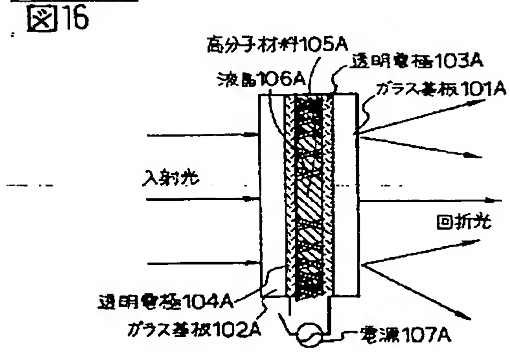
[Drawing 14]

図14



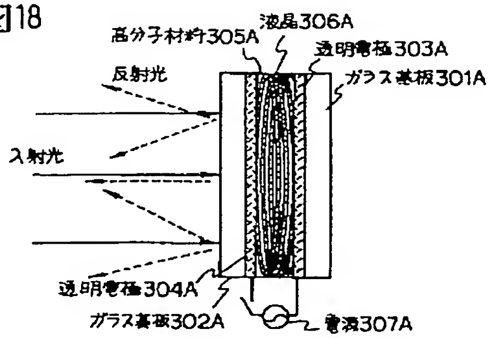
[Drawing 16]

図16



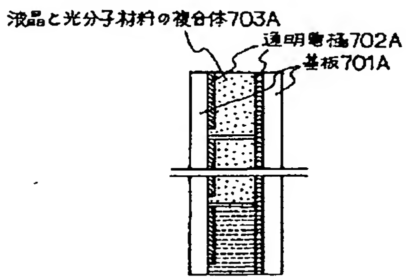
[Drawing 18]

図18



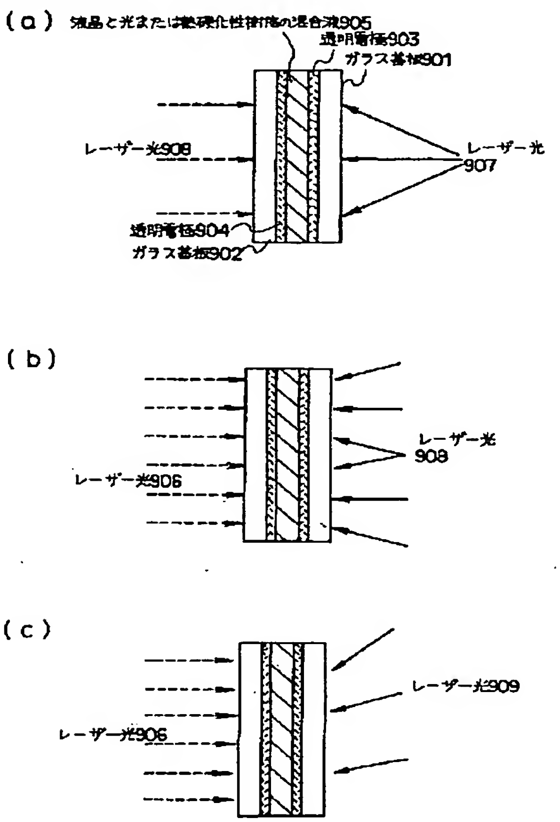
[Drawing 22]

図22



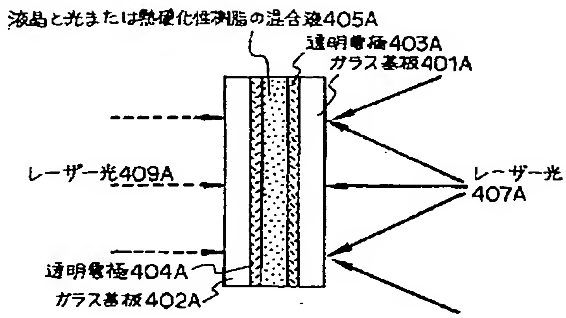
[Drawing 15]

図15

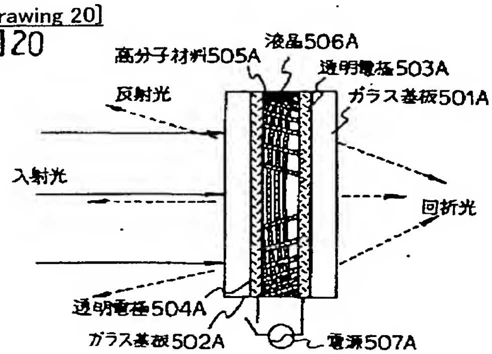


[Drawing 19]

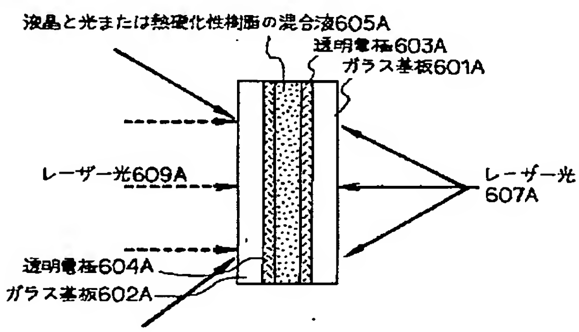
図19



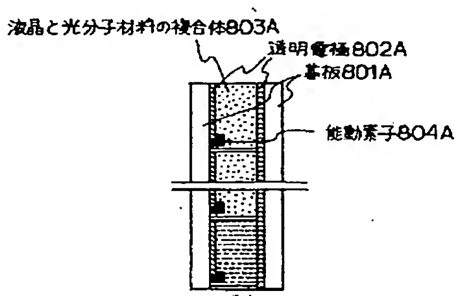
[Drawing 20]
図20



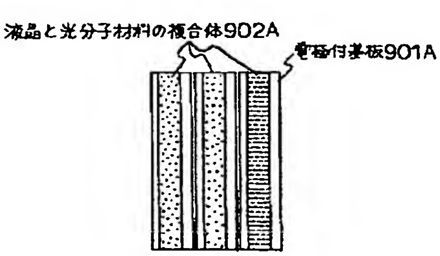
[Drawing 21]
図21



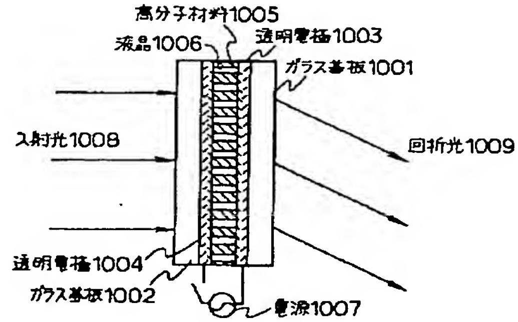
[Drawing 23]
図23



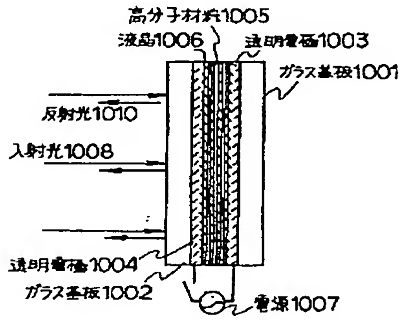
[Drawing 24]
図24



[Drawing 25]
図25



[Drawing 26]
図26



[Translation done.]